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Grupido

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(54) **DRIVER CIRCUIT FOR AN ELECTRIC VEHICLE AND A DIAGNOSTIC METHOD FOR DETERMINING WHEN A FIRST VOLTAGE DRIVER IS SHORTED TO A LOW VOLTAGE AND A SECOND VOLTAGE DRIVER IS SHORTED TO A HIGH VOLTAGE**

(75) Inventor: **Craig William Grupido**, Brighton, MI (US)

(73) Assignee: **LG Chem, Ltd.**, Seoul (KR)

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This patent is subject to a terminal disclaimer.

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CPC ***B60L 11/1803*** (2013.01); ***B60L 11/1861*** (2013.01); ***B60L 11/1864*** (2013.01); ***H02H 3/20*** (2013.01); *B60L 2240/547* (2013.01); *B60L 2240/549* (2013.01); *Y02T 10/7005* (2013.01); *Y02T 10/7044* (2013.01); *Y02T 10/7061* (2013.01)

(58) **Field of Classification Search**
CPC H02H 9/02; H02H 9/04; H02H 3/20; B60L 11/00; B60L 11/1805; B60L 11/1803; B60L 11/1861
USPC 307/10.1; 361/91.1, 92
See application file for complete search history.

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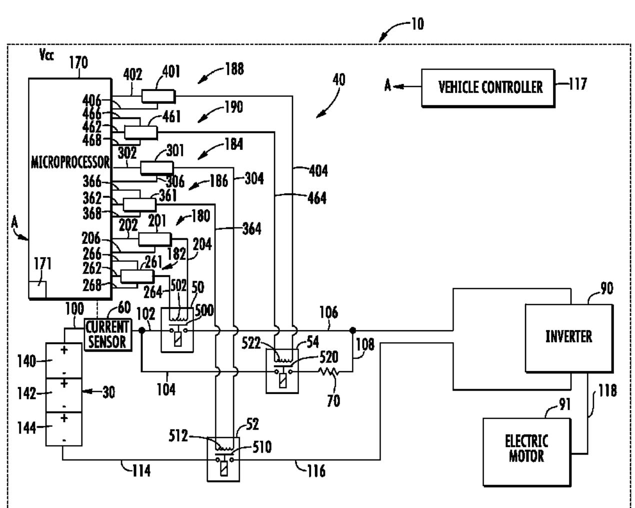
Primary Examiner — Carlos Amaya
(74) *Attorney, Agent, or Firm* — Buckert Patent & Trademark Law Firm, PC; John F. Buckert

(57) **ABSTRACT**

A driver circuit and a diagnostic method are provided. The driver circuit includes a first voltage driver, a second voltage driver, and a microprocessor. The microprocessor generates a first pulse width modulated signal to induce the first voltage driver to output a second pulse width modulated signal to energize a contactor coil. The microprocessor sets a first diagnostic flag equal to a first value if a first filtered voltage value is less than a first threshold value. The microprocessor sets a second diagnostic flag equal to a second value if a second filtered voltage value is greater than a second threshold value. The microprocessor stops generating the first pulse width modulated signal to de-energize the contactor coil if the first and second diagnostic flags are set equal to the first and second values, respectively.

14 Claims, 9 Drawing Sheets



(51) **Int. Cl.**

H02G 3/00	(2006.01)
B60L 11/18	(2006.01)
H02H 3/20	(2006.01)

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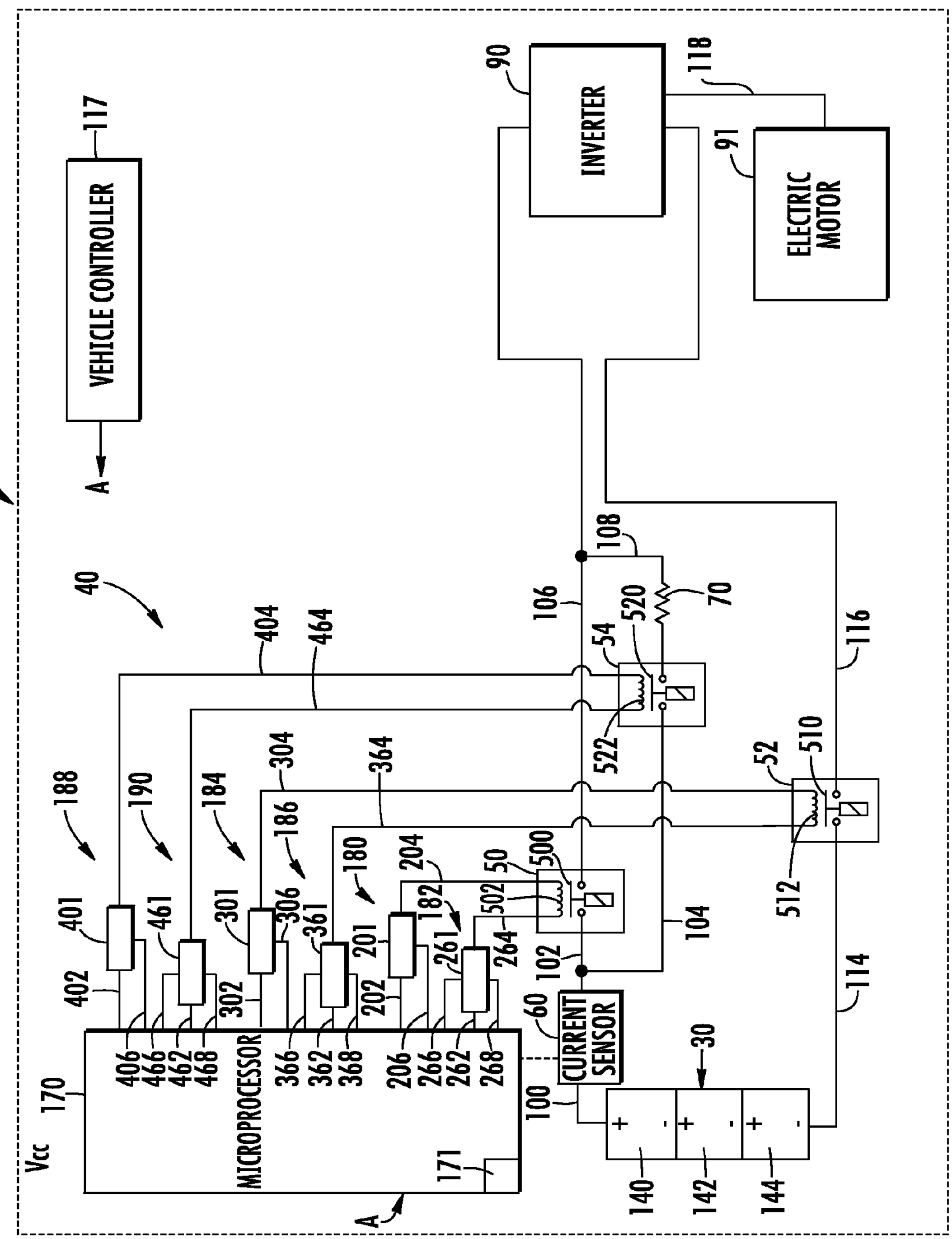
VEHICLE CONTROLLER
INVERTER
ELECTRIC MOTOR
MICROPROCESSOR
CURRENT SENSOR
Vcc
A
10
30
40
50
52
54
60
70
90
91
100
102
104
106
108
114
116
117
118
140
142
144
170
171
180
182
184
186
188
190
201
202
204
206
261
262
264
266
268
301
302
304
306
361
362
364
366
368
401
402
404
406
461
462
464
466
468
500
502
510
512
520
522

FIG. 1

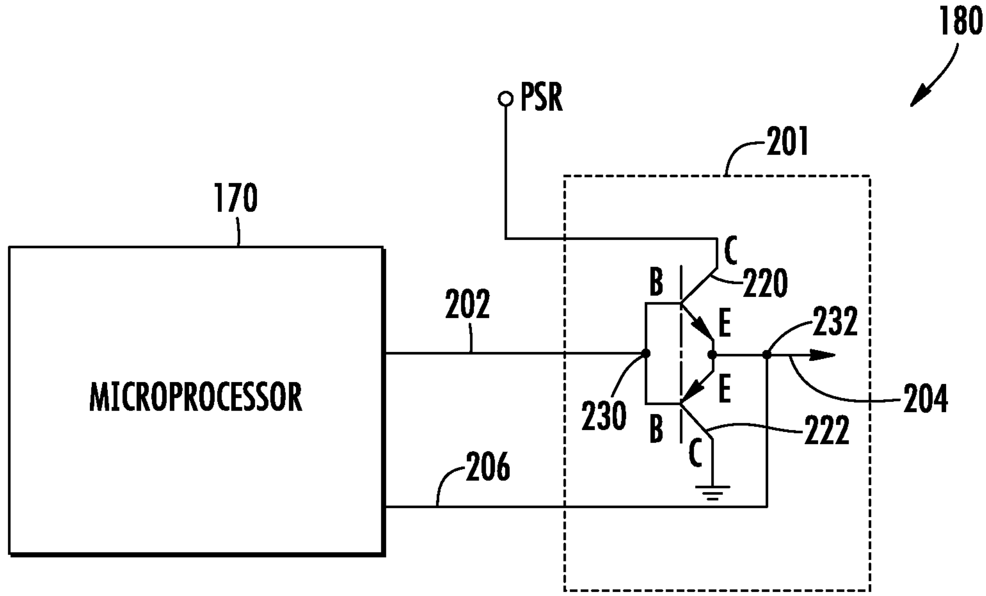
180
PSR
201
170
C
220
B
E
232
202
MICROPROCESSOR
E
204
230
B
222
C
206

FIG. 2

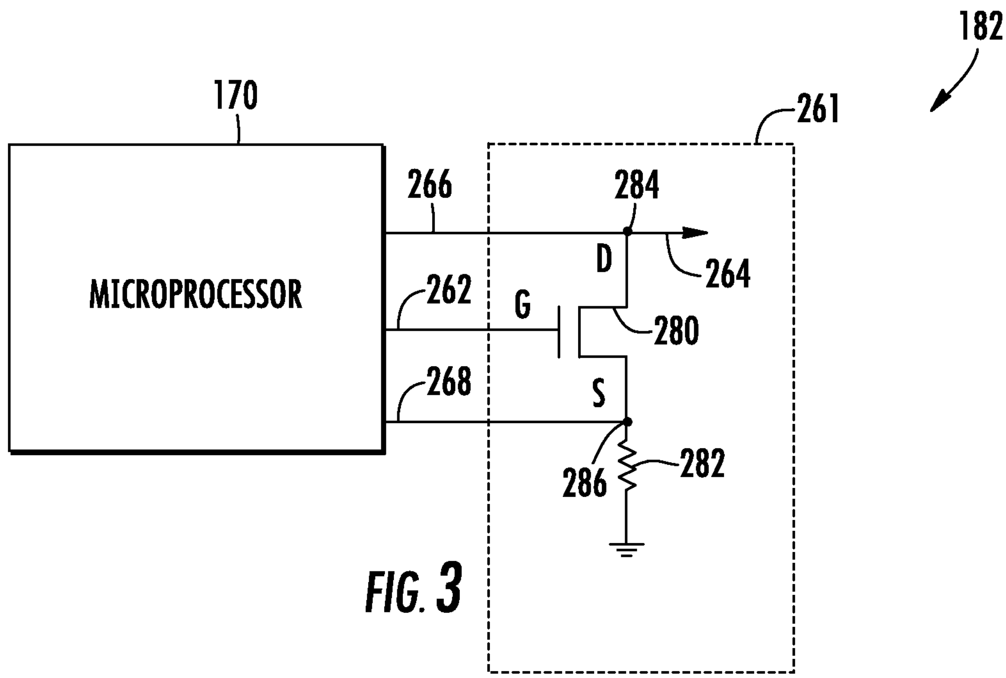
182
261
170
266
284
MICROPROCESSOR
D
264
262
G
280
268
S
286
282

FIG. 3

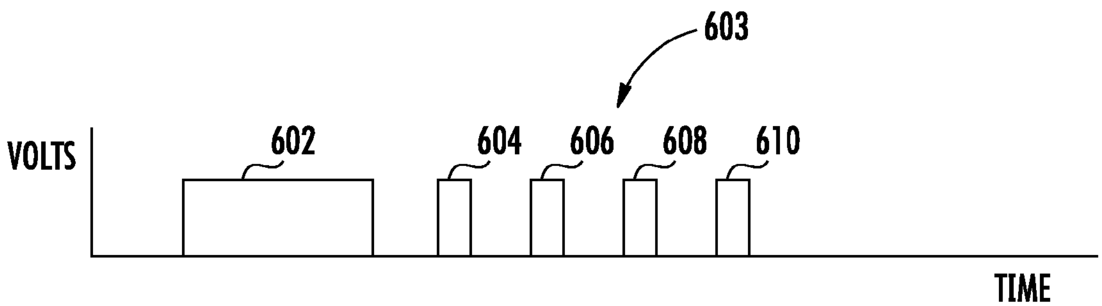

FIG. 4

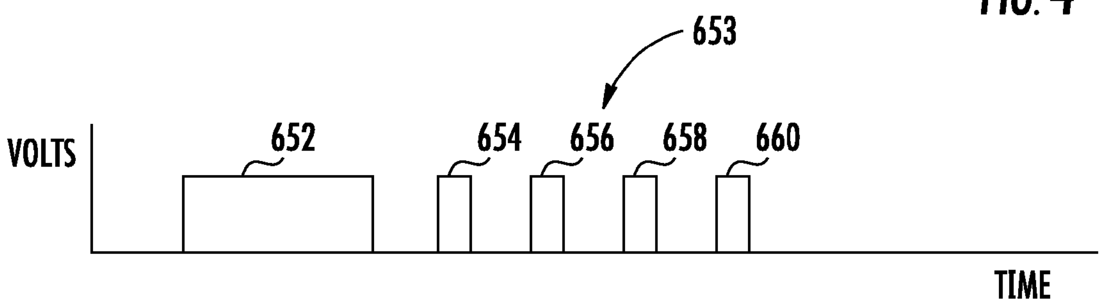

FIG. 5

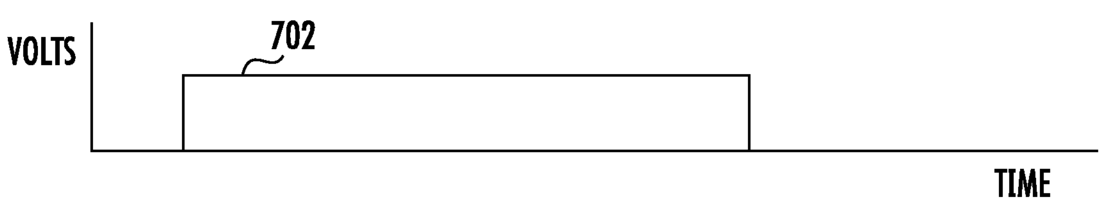

FIG. 6

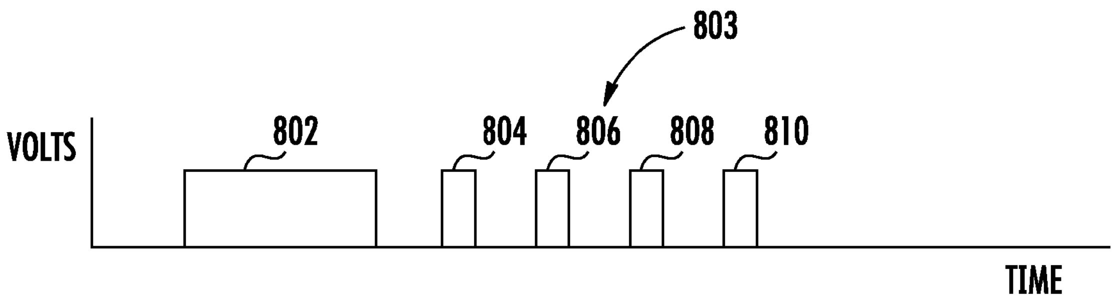

FIG. 7

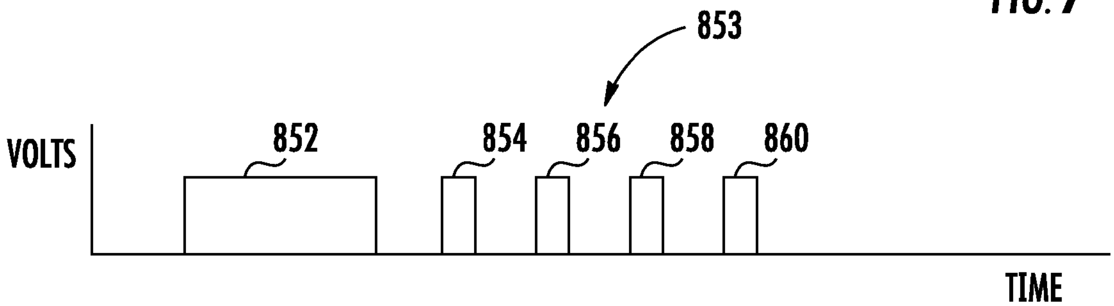

FIG. 8

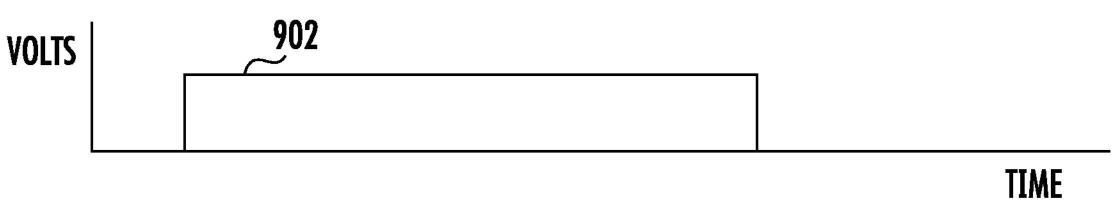

FIG. 9

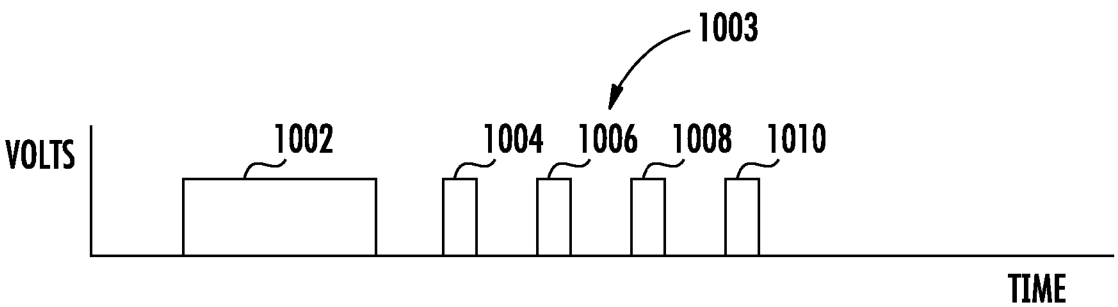

FIG. 10

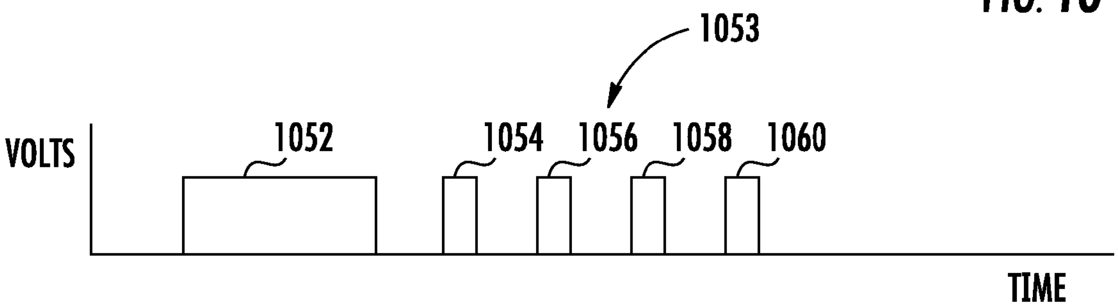

FIG. 11

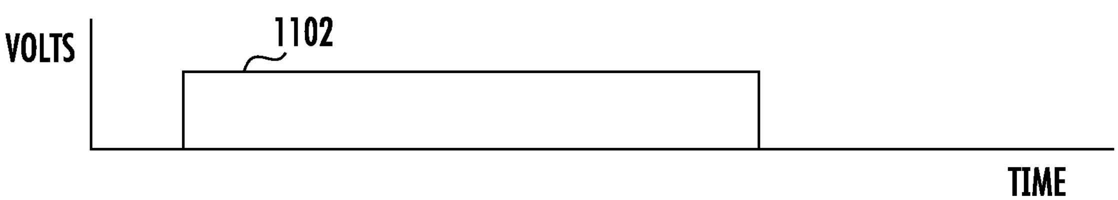

FIG. 12

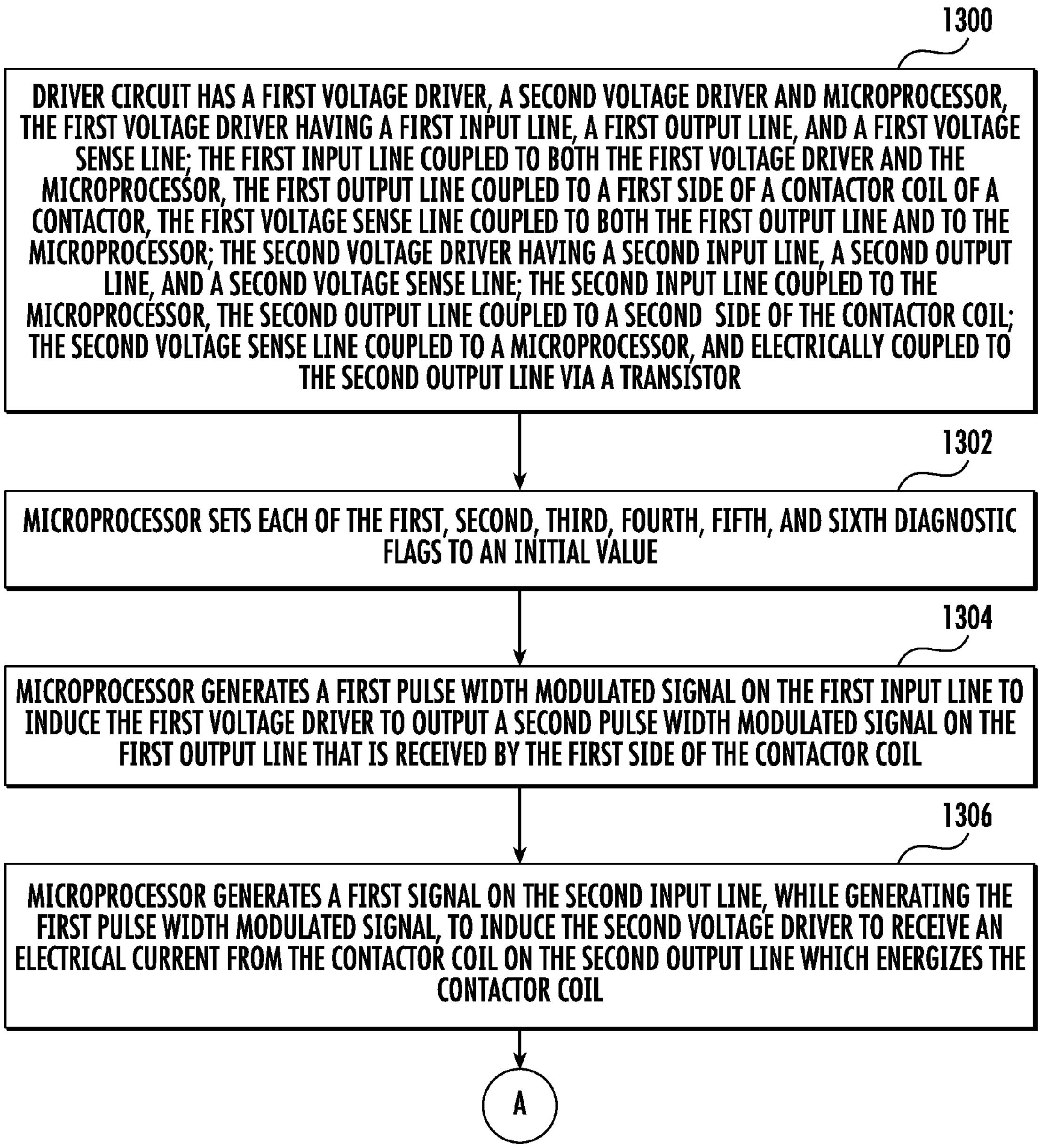
1300
DRIVER CIRCUIT HAS A FIRST VOLTAGE DRIVER, A SECOND VOLTAGE DRIVER AND MICROPROCESSOR, THE FIRST VOLTAGE DRIVER HAVING A FIRST INPUT LINE, A FIRST OUTPUT LINE, AND A FIRST VOLTAGE SENSE LINE; THE FIRST INPUT LINE COUPLED TO BOTH THE FIRST VOLTAGE DRIVER AND THE MICROPROCESSOR, THE FIRST OUTPUT LINE COUPLED TO A FIRST SIDE OF A CONTACTOR COIL OF A CONTACTOR, THE FIRST VOLTAGE SENSE LINE COUPLED TO BOTH THE FIRST OUTPUT LINE AND TO THE MICROPROCESSOR; THE SECOND VOLTAGE DRIVER HAVING A SECOND INPUT LINE, A SECOND OUTPUT LINE, AND A SECOND VOLTAGE SENSE LINE; THE SECOND INPUT LINE COUPLED TO THE MICROPROCESSOR, THE SECOND OUTPUT LINE COUPLED TO A SECOND SIDE OF THE CONTACTOR COIL; THE SECOND VOLTAGE SENSE LINE COUPLED TO A MICROPROCESSOR, AND ELECTRICALLY COUPLED TO THE SECOND OUTPUT LINE VIA A TRANSISTOR
1302
MICROPROCESSOR SETS EACH OF THE FIRST, SECOND, THIRD, FOURTH, FIFTH, AND SIXTH DIAGNOSTIC FLAGS TO AN INITIAL VALUE
1304
MICROPROCESSOR GENERATES A FIRST PULSE WIDTH MODULATED SIGNAL ON THE FIRST INPUT LINE TO INDUCE THE FIRST VOLTAGE DRIVER TO OUTPUT A SECOND PULSE WIDTH MODULATED SIGNAL ON THE FIRST OUTPUT LINE THAT IS RECEIVED BY THE FIRST SIDE OF THE CONTACTOR COIL
1306
MICROPROCESSOR GENERATES A FIRST SIGNAL ON THE SECOND INPUT LINE, WHILE GENERATING THE FIRST PULSE WIDTH MODULATED SIGNAL, TO INDUCE THE SECOND VOLTAGE DRIVER TO RECEIVE AN ELECTRICAL CURRENT FROM THE CONTACTOR COIL ON THE SECOND OUTPUT LINE WHICH ENERGIZES THE CONTACTOR COIL
A

FIG. 13

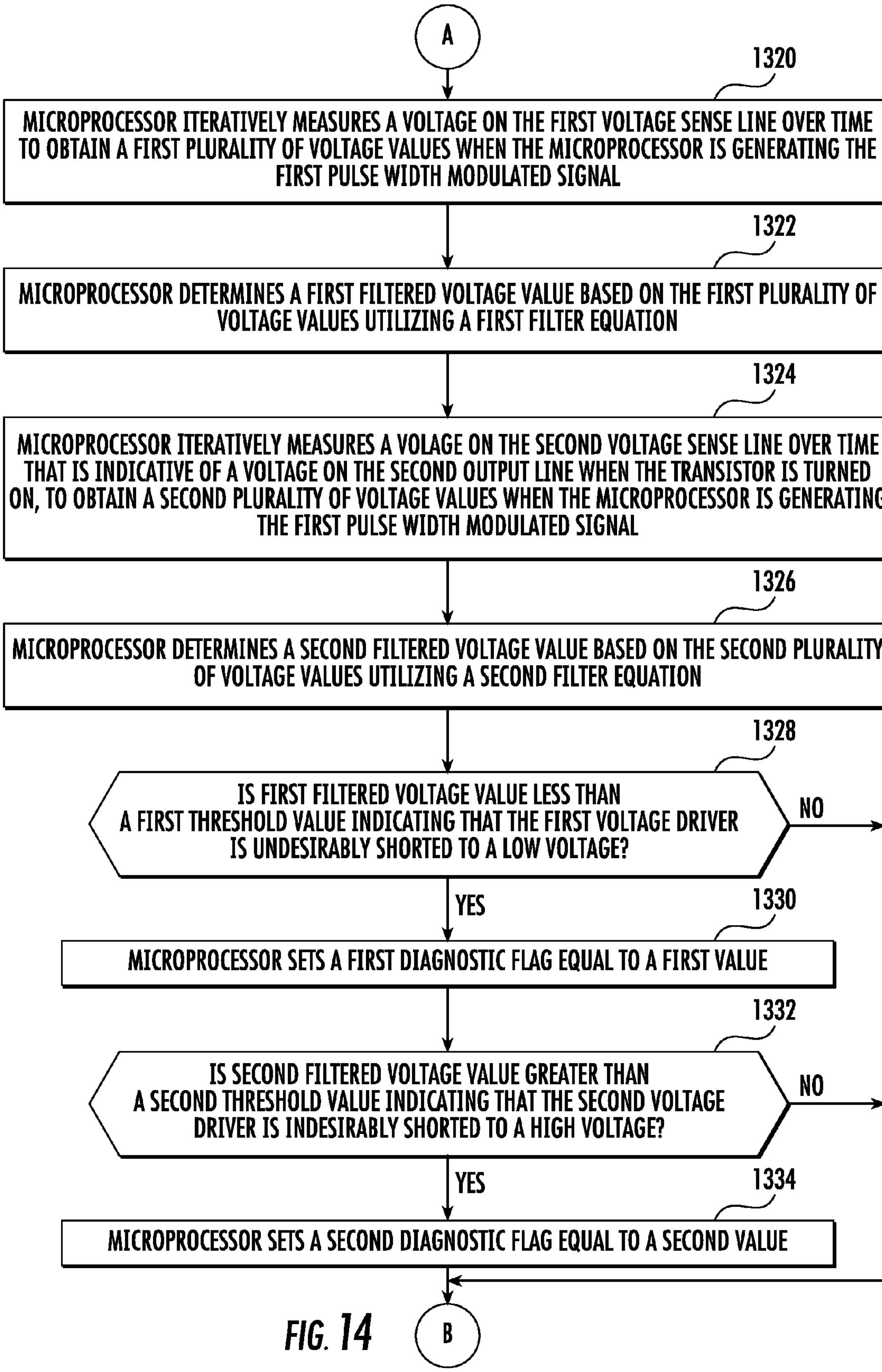
A
1320
MICROPROCESSOR ITERATIVELY MEASURES A VOLTAGE ON THE FIRST VOLTAGE SENSE LINE OVER TIME TO OBTAIN A FIRST PLURALITY OF VOLTAGE VALUES WHEN THE MICROPROCESSOR IS GENERATING THE FIRST PULSE WIDTH MODULATED SIGNAL
1322
MICROPROCESSOR DETERMINES A FIRST FILTERED VOLTAGE VALUE BASED ON THE FIRST PLURALITY OF VOLTAGE VALUES UTILIZING A FIRST FILTER EQUATION
1324
MICROPROCESSOR ITERATIVELY MEASURES A VOLAGE ON THE SECOND VOLTAGE SENSE LINE OVER TIME THAT IS INDICATIVE OF A VOLTAGE ON THE SECOND OUTPUT LINE WHEN THE TRANSISTOR IS TURNED ON, TO OBTAIN A SECOND PLURALITY OF VOLTAGE VALUES WHEN THE MICROPROCESSOR IS GENERATING THE FIRST PULSE WIDTH MODULATED SIGNAL
1326
MICROPROCESSOR DETERMINES A SECOND FILTERED VOLTAGE VALUE BASED ON THE SECOND PLURALITY OF VOLTAGE VALUES UTILIZING A SECOND FILTER EQUATION
1328
IS FIRST FILTERED VOLTAGE VALUE LESS THAN A FIRST THRESHOLD VALUE INDICATING THAT THE FIRST VOLTAGE DRIVER IS UNDESIRABLY SHORTED TO A LOW VOLTAGE?
NO
YES
1330
MICROPROCESSOR SETS A FIRST DIAGNOSTIC FLAG EQUAL TO A FIRST VALUE
1332
IS SECOND FILTERED VOLTAGE VALUE GREATER THAN A SECOND THRESHOLD VALUE INDICATING THAT THE SECOND VOLTAGE DRIVER IS INDESIRABLY SHORTED TO A HIGH VOLTAGE?
NO
YES
1334
MICROPROCESSOR SETS A SECOND DIAGNOSTIC FLAG EQUAL TO A SECOND VALUE
B

FIG. 14

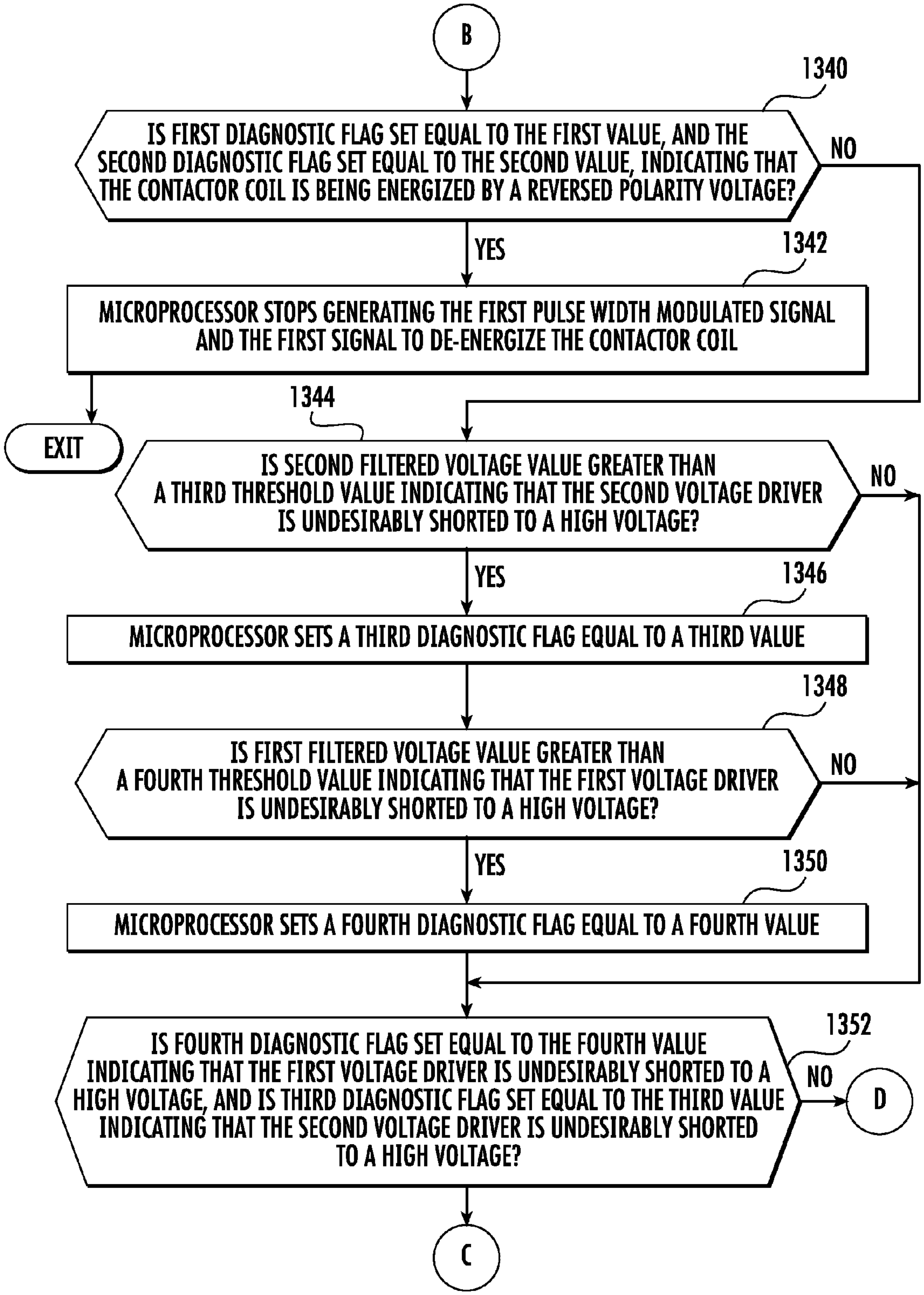
B
1340
IS FIRST DIAGNOSTIC FLAG SET EQUAL TO THE FIRST VALUE, AND THE SECOND DIAGNOSTIC FLAG SET EQUAL TO THE SECOND VALUE, INDICATING THAT THE CONTACTOR COIL IS BEING ENERGIZED BY A REVERSED POLARITY VOLTAGE?
NO
YES
1342
MICROPROCESSOR STOPS GENERATING THE FIRST PULSE WIDTH MODULATED SIGNAL AND THE FIRST SIGNAL TO DE-ENERGIZE THE CONTACTOR COIL
EXIT
1344
IS SECOND FILTERED VOLTAGE VALUE GREATER THAN A THIRD THRESHOLD VALUE INDICATING THAT THE SECOND VOLTAGE DRIVER IS UNDESIRABLY SHORTED TO A HIGH VOLTAGE?
NO
YES
1346
MICROPROCESSOR SETS A THIRD DIAGNOSTIC FLAG EQUAL TO A THIRD VALUE
1348
IS FIRST FILTERED VOLTAGE VALUE GREATER THAN A FOURTH THRESHOLD VALUE INDICATING THAT THE FIRST VOLTAGE DRIVER IS UNDESIRABLY SHORTED TO A HIGH VOLTAGE?
NO
YES
1350
MICROPROCESSOR SETS A FOURTH DIAGNOSTIC FLAG EQUAL TO A FOURTH VALUE
1352
IS FOURTH DIAGNOSTIC FLAG SET EQUAL TO THE FOURTH VALUE INDICATING THAT THE FIRST VOLTAGE DRIVER IS UNDESIRABLY SHORTED TO A HIGH VOLTAGE, AND IS THIRD DIAGNOSTIC FLAG SET EQUAL TO THE THIRD VALUE INDICATING THAT THE SECOND VOLTAGE DRIVER IS UNDESIRABLY SHORTED TO A HIGH VOLTAGE?
NO
D
C

FIG. 15

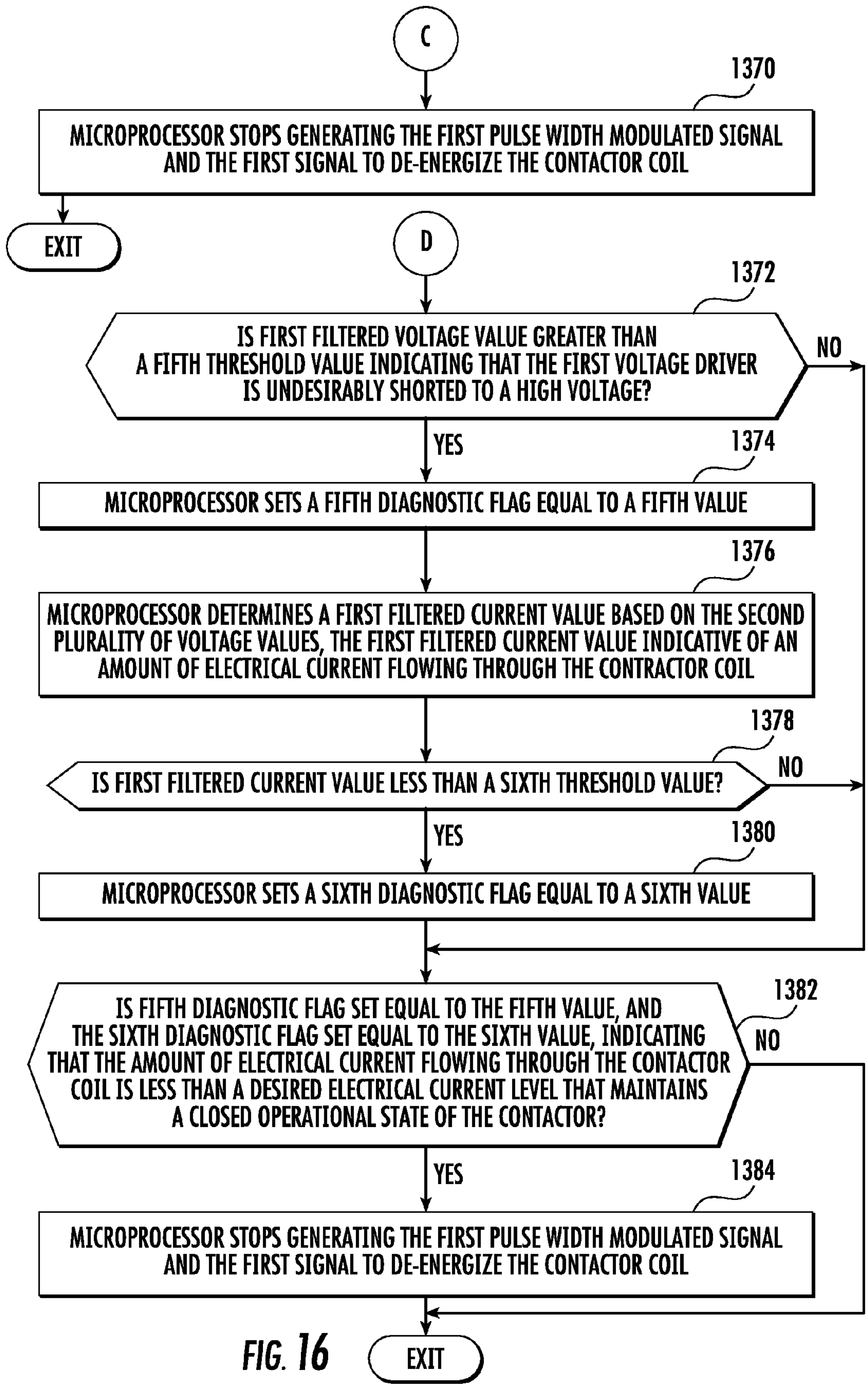
C
1370
MICROPROCESSOR STOPS GENERATING THE FIRST PULSE WIDTH MODULATED SIGNAL AND THE FIRST SIGNAL TO DE-ENERGIZE THE CONTACTOR COIL
EXIT
D
1372
IS FIRST FILTERED VOLTAGE VALUE GREATER THAN A FIFTH THRESHOLD VALUE INDICATING THAT THE FIRST VOLTAGE DRIVER IS UNDESIRABLY SHORTED TO A HIGH VOLTAGE?
NO
YES
1374
MICROPROCESSOR SETS A FIFTH DIAGNOSTIC FLAG EQUAL TO A FIFTH VALUE
1376
MICROPROCESSOR DETERMINES A FIRST FILTERED CURRENT VALUE BASED ON THE SECOND PLURALITY OF VOLTAGE VALUES, THE FIRST FILTERED CURRENT VALUE INDICATIVE OF AN AMOUNT OF ELECTRICAL CURRENT FLOWING THROUGH THE CONTRACTOR COIL
1378
IS FIRST FILTERED CURRENT VALUE LESS THAN A SIXTH THRESHOLD VALUE?
NO
YES
1380
MICROPROCESSOR SETS A SIXTH DIAGNOSTIC FLAG EQUAL TO A SIXTH VALUE
1382
IS FIFTH DIAGNOSTIC FLAG SET EQUAL TO THE FIFTH VALUE, AND THE SIXTH DIAGNOSTIC FLAG SET EQUAL TO THE SIXTH VALUE, INDICATING THAT THE AMOUNT OF ELECTRICAL CURRENT FLOWING THROUGH THE CONTACTOR COIL IS LESS THAN A DESIRED ELECTRICAL CURRENT LEVEL THAT MAINTAINS A CLOSED OPERATIONAL STATE OF THE CONTACTOR?
NO
YES
1384
MICROPROCESSOR STOPS GENERATING THE FIRST PULSE WIDTH MODULATED SIGNAL AND THE FIRST SIGNAL TO DE-ENERGIZE THE CONTACTOR COIL
EXIT

FIG. 16

DRIVER CIRCUIT FOR AN ELECTRIC VEHICLE AND A DIAGNOSTIC METHOD FOR DETERMINING WHEN A FIRST VOLTAGE DRIVER IS SHORTED TO A LOW VOLTAGE AND A SECOND VOLTAGE DRIVER IS SHORTED TO A HIGH VOLTAGE

BACKGROUND

The inventor herein has recognized a need for an improved driver circuit for an electric vehicle and a diagnostic method for determining when a first voltage driver is shorted to a low voltage and a second voltage driver is shorted to a high voltage.

SUMMARY

A driver circuit for an electric vehicle in accordance with an exemplary embodiment is provided. The driver circuit includes a first voltage driver having a first input line, a first output line, and a first voltage sense line. The first input line is coupled to both the first voltage driver and a microprocessor. The first output line is coupled to a first side of a contactor coil of a contactor. The first voltage sense line is coupled to both the first output line and to the microprocessor. The driver circuit further includes a second voltage driver having a second input line, a second output line, and a second voltage sense line. The second input line is coupled to the microprocessor. The second output line is coupled to a second side of the contactor coil. The second voltage sense line is coupled to the microprocessor. The microprocessor is configured to generate a first pulse width modulated signal on the first input line to induce the first voltage driver to output a second pulse width modulated signal on the first output line that is received by the first side of the contactor coil to energize the contactor coil. The microprocessor is further configured to iteratively measure a voltage on the first voltage sense line over time to obtain a first plurality of voltage values when the microprocessor is generating the first pulse width modulated signal. The microprocessor is further configured to determine a first filtered voltage value based on the first plurality of voltage values. The microprocessor is further configured to set a first diagnostic flag equal to a first value if the first filtered voltage value is less than a first threshold value. The microprocessor is further configured to iteratively measure a voltage on the second voltage sense line over time that is indicative of a voltage on the second output line to obtain a second plurality of voltage values when the microprocessor is generating the first pulse width modulated signal. The microprocessor is further configured to determine a second filtered voltage value based on the second plurality of voltage values. The microprocessor is further configured to set a second diagnostic flag equal to a second value if the second filtered voltage value is greater than a second threshold value. The microprocessor is further configured to stop generating the first pulse width modulated signal to de-energize the contactor coil if the first diagnostic flag is set equal to the first value, and the second diagnostic flag is set equal to the second value.

A diagnostic method for a driver circuit for an electric vehicle in accordance with another exemplary embodiment is provided. The driver circuit has a first voltage driver, a second voltage driver, and a microprocessor. The first voltage driver has a first input line, a first output line, and a first voltage sense line. The first input line is coupled to both the first voltage driver and the microprocessor. The first output line is coupled to a first side of a contactor coil of a contactor. The first voltage sense line is coupled to both the first output line and to the microprocessor. The second voltage driver has a second input line, a second output line, and a second voltage sense line. The second input line is coupled to the microprocessor. The second output line is coupled to a second side of the contactor coil. The second voltage sense line is coupled to the microprocessor. The method includes generating a first pulse width modulated signal on the first input line utilizing the microprocessor to induce the first voltage driver to output a second pulse width modulated signal on the first output line that is received by the first side of the contactor coil to energize the contactor coil. The method further includes iteratively measuring a voltage on the first voltage sense line over time utilizing the microprocessor to obtain a first plurality of voltage values when the microprocessor is generating the first pulse width modulated signal. The method further includes determining a first filtered voltage value based on the first plurality of voltage values utilizing the microprocessor. The method further includes setting a first diagnostic flag equal to a first value if the first filtered voltage value is less than a first threshold value utilizing the microprocessor. The method further includes iteratively measuring a voltage on the second voltage sense line over time that is indicative of a voltage on the second output line utilizing the microprocessor to obtain a second plurality of voltage values when the microprocessor is generating the first pulse width modulated signal. The method further includes determining a second filtered voltage value based on the second plurality of voltage values utilizing the microprocessor. The method further includes setting a second diagnostic flag equal to a second value if the second filtered voltage value is greater than a second threshold value utilizing the microprocessor. The method further includes stopping the generating of the first pulse width modulated signal to de-energize the contactor coil if the first diagnostic flag is set equal to the first value and the second diagnostic flag is set equal to the second value, utilizing the microprocessor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an electric vehicle having a driver circuit in accordance with an exemplary embodiment;

FIG. **2** is a schematic of a first voltage driver utilized in the driver circuit of FIG. **1**;

FIG. **3** is a schematic of a second voltage driver utilized in the driver circuit of FIG. **1**;

FIG. **4** is a schematic of a first set of voltage pulses output by the driver circuit of FIG. **1**;

FIG. **5** is a schematic of a second set of voltage pulses output by the driver circuit of FIG. **1**;

FIG. **6** is a schematic of a signal output by the driver circuit of FIG. **1**;

FIG. **7** is a schematic of a third set of voltage pulses output by the driver circuit of FIG. **1**;

FIG. **8** is a schematic of a fourth set of voltage pulses output by the driver circuit of FIG. **1**;

FIG. **9** is a schematic of another signal output by the driver circuit of FIG. **1**;

FIG. **10** is a schematic of a fifth set of voltage pulses output by the driver circuit of FIG. **1**;

FIG. **11** is a schematic of a sixth set of voltage pulses output by the driver circuit of FIG. **1**;

FIG. **12** is a schematic of another signal output by the driver circuit of FIG. **1**; and

FIGS. **13-16** are flowcharts of a diagnostic method in accordance with another exemplary embodiment.

DETAILED DESCRIPTION

Referring to FIGS. **1-3**, an electric vehicle **10** having a driver circuit **40** in accordance with an exemplary embodiment is provided. The electric vehicle **10** further includes a battery pack **30**, a main contactor **50**, a grounding contactor **52**, a pre-charge contactor **54**, a current sensor **60**, a resistor **70**, a high voltage inverter **90**, an electrical motor **91**, electrical lines **100**, **102**, **104**, **106**, **108**, **114**, **116**, **118**, and a vehicle controller **117**. An advantage of the driver circuit **40** is that the driver circuit **40** performs a diagnostic algorithm to determine when the driver circuit **40** has a first voltage driver that is shorted to a low voltage and a second voltage driver that is shorted to a high voltage, as will be explained in greater detail below.

Before explaining the structure and operation of the electric vehicle **10**, a brief explanation of some of the terms utilized herein will be provided.

The term "filtered voltage value" refers to a voltage value that is determined based on a plurality of voltage values. A filtered voltage value can be determined utilizing a filter equation.

The term "filtered current value" refers to a current value that is determined based on a plurality of voltage values or a plurality of current values. A filtered current value can be determined utilizing a filter equation.

The term "filter equation" refers to an equation that is used to calculate a value based on a plurality of values. In exemplary embodiments, a filter equation can comprise a first order lag filter or an integrator for example. Of course, other types of filter equations known to those skilled in the art could be utilized.

The term "high voltage" refers to a voltage greater than an expected voltage during a predetermined operational mode of the driver circuit. For example, if an expected voltage at a predetermined location in the driver circuit is 4 volts (e.g., 12 volts at a 30% duty cycle) in a predetermined operational mode of the driver circuit, an actual voltage of 4.5 volts at the predetermined location in the driver circuit could be considered a high voltage.

The term "high logic voltage" refers to a voltage in the driver circuit that corresponds to a Boolean logic value of "1."

The battery pack **30** is configured to output an operational voltage to the high voltage inverter **90** which outputs operational voltages to the electric motor **91** via the electrical lines **118**. The battery pack **30** includes battery modules **140**, **142**, **144** electrically coupled in series with one another.

The driver circuit **40** is configured to control operational positions of the main contactor **50**, the grounding contactor **52**, and the pre-charge contactor **54**. The driver circuit **40** includes a microprocessor **170**, a first voltage driver **180**, a second voltage driver **182**, a third voltage driver **184**, a fourth voltage driver **186**, a fifth voltage driver **188**, and a sixth voltage driver **190**.

The microprocessor **170** is configured to generate control signals for controlling operation of the first voltage driver **180**, the second voltage driver **182**, the third voltage driver **184**, the fourth voltage driver **186**, the fifth voltage driver **188**, and the sixth voltage driver **190**. The microprocessor **170** is further configured to execute a software program stored in a memory device **171** for implementing a diagnostic algorithm associated with the driver circuit **40** as will be explained below. The memory device **171** is configured to store software algorithms, values, and status flags therein. The microprocessor **170** is operably coupled to a Vcc voltage source that supplies an operational voltage (e.g., 5 Volts) to the microprocessor **170**.

Before explaining the diagnostic algorithm associated with the driver circuit **40** in accordance with an exemplary embodiment, the structure and operation of the driver circuit **40** will be explained.

Referring to FIGS. **1** and **2**, the first voltage driver **180** and the second voltage driver **182** are utilized to energize the main contactor coil **502** to induce the contact **500** to have a closed operational position, and to de-energize the main contactor coil **502** to induce the contact **500** to have an open operational position.

Referring to FIGS. **1** and **4-6**, during operation, when the microprocessor **170** outputs both the initial voltage pulse **602**, and the first signal **702** on the input lines **202**, **262**, respectively, of the first and second voltage drivers **180**, **182**, respectively; the voltage drivers **180**, **182** energize the main contactor coil **502** to induce the contact **500** to have a closed operational position. In particular, in response to the first voltage driver **180** receiving the initial voltage pulse **602**, the first voltage driver **180** outputs the initial voltage pulse **652** to energize the main contactor coil **502**.

After generating the initial voltage pulse **602**, the microprocessor **170** outputs the pulse width modulated signal **603** having the voltage pulses **604**, **606**, **608**, **610** with a duty cycle of about 30%. Of course, the duty cycle of the voltage pulses **604**, **606**, **608**, **610** could be less than 30% or greater than 30%.

Further, after generating the initial voltage pulse **602**, the microprocessor **170** continues outputting the first signal **702** which has a high logic voltage while generating the voltage pulses **604**, **606**, **608**, **610**. The first signal **702** turns on the transistor **280** in the second voltage driver **182**.

In particular, in response to the first voltage driver **180** receiving the pulse width modulated signal **603**, the first voltage driver **180** outputs the pulse width modulated signal **653** (shown in FIG. **5**) to maintain energization the main contactor coil **502**. The pulse width modulated signal **653** includes the voltage pulses **654**, **656**, **658**, **660** with a duty cycle of about 30%. Of course, the duty cycle of the voltage pulses **654**, **656**, **658**, **660** could be less than 30% or greater than 30%.

When the microprocessor **170** stops outputting the pulse width modulated signal **603** and the first signal **702** on the input lines **202**, **262**, respectively, of the first and second voltage drivers **180**, **182**, respectively, the voltage drivers **180**, **182** de-energize the main contactor coil **502** to induce the contact **500** to have an open operational position.

Referring to FIGS. **1** and **2**, the first voltage driver **180** includes a driver circuit **201**, an input line **202**, an output line **204**, and a voltage sense line **206**. The input line **202** is coupled to both the microprocessor **170** and to the driver circuit **201**. The output line **204** is electrically coupled to a first side of the main contactor coil **502**. The voltage sense line **206** is coupled to both the output line **204** and to the microprocessor **170**.

In one exemplary embodiment, the driver circuit **201** includes transistors **220**, **222**. The transistor **220** has: (i) a base (B) coupled to a node **230** that is further coupled to the microprocessor **170**, (ii) a collector (C) coupled to a PSR voltage source, and (iii) an emitter coupled to a node **232** which is further coupled to the output line **204**. The transistor **222** has: (i) a base (B) coupled to the node **230** that is further coupled to the microprocessor **170**, (ii) a collector (C) coupled to electrical ground, and (iii) an emitter coupled to the node **232**. When the microprocessor **170** applies a high logic voltage to node **230**, the transistor **220** is turned on and the transistor **222** is turned off and a voltage (e.g., 12 volts) from the PSR voltage source is applied to the node **232** and the output line **204** which is further applied to a first end of the main contactor coil **502**. Alternately, when the microprocessor **170** stops applying the high logic voltage to node **230**, the transistor **220** is turned off and the transistor **222** is turned on and a ground voltage is applied to the node **232** and the output line **204** which is further applied to the first end of the main contactor coil **502**.

Referring to FIGS. **1** and **3**, the second voltage driver **182** includes a driver circuit **261**, an input line **262**, an output line **264**, a voltage sense line **266**, and a voltage sense line **268**. The input line **262** is coupled to both the microprocessor **170** and to the driver circuit **261**. The output line **264** is electrically coupled to a second side of the main contactor coil **502**. The voltage sense line **266** coupled to both the output line **264** and to the microprocessor **170**. When the main contactor coil **502** is energized, the voltage sense line **268** receives a voltage indicative of a first current in the main contactor coil **502** and is coupled to the microprocessor **170**.

In one exemplary embodiment, the driver circuit **261** includes a transistor **280** and a resistor **282**. The transistor **280** has: (i) a gate (G) coupled to the microprocessor **170**, (ii) a drain (D) coupled to a node **284** that is further coupled to both the voltage sense line **266** and to the output line **264**, and (iii) a source (S) coupled to a resistor **282**. The resistor **282** is coupled between the source (S) and electrical ground. A node **286** at a first end of the resistor **282** is further coupled to the microprocessor **170** through the voltage sense line **268**. When the microprocessor **170** applies a high logic voltage to the gate (G), the transistor **280** turns on and allows electrical current from the main contactor coil **502** to flow through the transistor **280** and the resistor **282** to ground. Alternately, when the microprocessor **170** stops applying the high logic voltage to the gate (G), the transistor **280** turns off and does not allow electrical current to flow through the main contactor coil **502**, the transistor **280**, and the resistor **282**.

Referring to FIG. **1**, the third voltage driver **184** and the fourth voltage driver **186** are utilized to energize the grounding contactor coil **512** to induce the contact **510** to have a closed operational position, and to de-energize the grounding contactor coil **512** to induce the contact **510** to have an open operational position.

Referring to FIGS. **1** and **7-9**, during operation, when the microprocessor **170** outputs both the initial voltage pulse **802**, and the first signal **902** on the input lines **302**, **362** of the third and fourth voltage drivers **184**, **186**, respectively; the voltage drivers **184**, **186** energize the grounding contactor coil **512** to induce the contact **510** to have a closed operational position. In particular, in response to the third voltage driver **184** receiving the initial voltage pulse **802**, the third voltage driver **184** outputs the initial voltage pulse **852** to energize the grounding contactor coil **512**.

After generating the initial voltage pulse **802**, the microprocessor **170** outputs the pulse width modulated signal **803** having the voltage pulses **804**, **806**, **808**, **810** with a duty cycle of about 30%. Of course, the duty cycle of the voltage pulses **804**, **806**, **808**, **810** could be less than 30% or greater than 30%.

Further, after generating the initial voltage pulse **802**, the microprocessor **170** continues outputting the first signal **902** which has a high logic voltage while generating the voltage pulses **804**, **806**, **808**, **810**, to continue to turn on a transistor, like the transistor **280**, in the fourth voltage driver **186**.

In particular, in response to the third voltage driver **184** receiving the pulse width modulated signal **803**, the third voltage driver **184** outputs the pulse width modulated signal **853** (shown in FIG. **8**) to energize the grounding contactor coil **512**. The pulse width modulated signal **853** includes the voltage pulses **854**, **856**, **858**, **860** having a duty cycle of about 30%. Of course, the duty cycle of the voltage pulses **854**, **856**, **858**, **860** could be less than 30% or greater than 30%.

When the microprocessor **170** stops outputting the pulse width modulated signal **803**, and the first signal **902** on the input lines **302**, **362**, respectively, of the third and fourth voltage drivers **184**, **186**, respectively, the voltage drivers **184**, **186** de-energize the grounding contactor coil **512** to induce the contact **510** to have an open operational position.

Referring to FIGS. **1** and **2**, the third voltage driver **184** includes a driver circuit **301**, an input line **302**, an output line **304**, and a voltage sense line **306**. The input line **302** is coupled to both the microprocessor **170** and to the driver circuit **301**. The output line **304** is electrically coupled to a first side of the grounding contactor coil **512**. The voltage sense line **306** is coupled to both the output line **304** and to the microprocessor **170**. In one exemplary embodiment, the structure of the driver circuit **301** is identical to the structure of the driver circuit **201** discussed above.

Referring to FIGS. **1** and **3**, the fourth voltage driver **186** includes a driver circuit **361**, an input line **362**, an output line **364**, a voltage sense line **366**, and a voltage sense line **368**. The input line **362** is coupled to both the microprocessor **170** and to the driver circuit **361**. The output line **364** is electrically coupled to a second side of the grounding contactor coil **512**. The voltage sense line **366** coupled to both the output line **364** and to the microprocessor **170**. When the grounding contactor coil **512** is energized, the voltage sense line **368** receives a signal indicative of a second current in the grounding contactor coil **512** and is coupled to the microprocessor **170**. In one exemplary embodiment, the structure of the driver circuit **361** is identical to the structure of the driver circuit **261**.

The fifth voltage driver **188** and the sixth voltage driver **190** are utilized to energize the pre-charge contactor coil **522** to induce the contact **520** to have a closed operational position, and to de-energize the pre-charge contactor coil **522** to induce the contact **520** to have an open operational position.

Referring to FIGS. **1** and **10-12**, during operation, when the microprocessor **170** outputs both the initial voltage pulse **1002**, and the first signal **1102** on the input lines **402**, **462**, respectively, of the fifth and sixth voltage drivers **188**, **190**, respectively; the voltage drivers **188**, **190** energize the pre-charge contactor coil **522** to induce the contact **520** to have a closed operational position. In particular, in response to the fifth voltage driver **188** receiving the initial voltage pulse **1002**, the fifth voltage driver **188** outputs the initial voltage pulse **1052** to energize the grounding contactor coil **512**.

After generating the initial voltage pulse **1002**, the microprocessor **170** outputs the pulse width modulated signal **1003** having the voltage pulses **1004**, **1006**, **1008**, **1010** with a duty cycle of about 30%. Of course, the duty cycle of the voltage pulses **1004**, **1006**, **1008**, **1010** could be less than 30% or greater than 30%.

Further, after generating the initial voltage pulse **1002**, the microprocessor **170** continues outputting the first signal **1102** which has a high logic voltage while generating the voltage pulses **1004**, **1006**, **1008**, **1010**, to continue to turn on a transistor, like the transistor **280**, in the sixth voltage driver **190**.

In response to the fifth voltage driver **188** receiving the pulse width modulated signal **1003**, the fifth voltage driver **188** outputs the pulse width modulated signal **1053** to energize the pre-charge contactor coil **522**. The pulse width modulated signal **1053** includes the voltage pulses **1054**, **1056**, **1058**, **1060** having a duty cycle of about 30%. Of course, the duty cycle of the voltage pulses **1054**, **1056**, **1058**, **1060** could be less than 30% or greater than 30%.

When the microprocessor **170** stops outputting the pulse width modulated signal **1003**, and the first signal **1102** on the input lines **402**, **462**, respectively, of the fifth and sixth voltage drivers **188**, **190**, respectively; the voltage drivers **188**, **190** de-energize the pre-charge contactor coil **522** to induce the contact **520** to have an open operational position.

The fifth voltage driver **188** includes a driver circuit **401**, an input line **402**, an output line **404**, and a voltage sense line **406**. The input line **402** is coupled to both the microprocessor **170** and to the driver circuit **401**. The output line **404** is electrically coupled to a first side of the pre-charge contactor coil **522**. The voltage sense line **406** is coupled to both the output line **404** and to the microprocessor **170**. In one exemplary embodiment, the structure of the driver circuit **401** is identical to the structure of the driver circuit **201** discussed above.

The sixth voltage driver **190** includes a driver circuit **461**, an input line **462**, an output line **464**, a voltage sense line **466**, a voltage sense line **468**. The input line **462** is coupled to both the microprocessor **170** and to the driver circuit **461**. The output line **464** is electrically coupled to a second side of the pre-charge contactor coil **522**. The voltage sense line **466** coupled to both the output line **464** and to the microprocessor **170**. When the pre-charge contactor coil **522** is energized, the voltage sense line **468** receives a signal indicative of a third current in the pre-charge contactor coil **522** and is coupled to the microprocessor **170**. In one exemplary embodiment, the structure of the driver circuit **461** is identical to the structure of the driver circuit **261**.

The main contactor **50** is electrically coupled in series with the battery pack **30**, the current sensor **60** and the inverter **90**. In particular, a positive voltage terminal of the battery pack **100** is electrically coupled to the current sensor **60** via the electrical line **100**. The current sensor **60** is electrically coupled to a first end of the contact **500** of the main contactor **50** via the electrical line **102**. Also, a second end of the contact **500** is electrically coupled to the inverter **90** via the electrical line **106**. When the main contactor coil **502** is energized, the contact **500** has a closed operational position and electrically couples a positive voltage terminal of the battery pack **30** to the inverter **90**. When the main contactor coil **502** is de-energized, the contact **500** has an open operational position and electrically de-couples the positive voltage terminal of the battery pack **30** from the inverter **90**.

The grounding contactor **52** is electrically coupled in series between the battery pack **30** and the inverter **90**. A negative voltage terminal of the battery pack **30** is electrically coupled to a first end of the contact **510** of the grounding contactor **52** via the electrical line **114**. Also, a second end of the contact **510** is electrically coupled to the inverter **90** via the electrical line **116**. When the grounding contactor coil **512** is energized, the contact **510** has a closed operational position and electrically couples a negative voltage terminal of the battery pack **30** to the inverter **90**. When the grounding contactor coil **512** is de-energized, the contact **510** has an open operational position and electrically de-couples the negative voltage terminal of the battery pack **30** from the inverter **90**.

The pre-charge contactor **54** is electrically coupled in parallel to the main contactor **50**. A first end of the contact **520** is electrically coupled to the electrical line **102** via the electrical line **104**. A second end of the contact **520** is electrically coupled to the electrical line **106** via the resistor **70** and the electrical line **108**. When the pre-charge contactor coil **522** is energized, the contact **520** has a closed operational position and electrically couples a positive voltage terminal of the battery pack **30** to the inverter **90**. When the pre-charge contactor coil **522** is de-energized, the contact **520** has an open operational position and electrically de-couples the positive voltage terminal of the battery pack **30** from the inverter **90**.

The current sensor **60** is configured to generate a signal indicative of a total amount of current being supplied by the battery pack **30** to the inverter **90**. The microprocessor **170** receives the signal from the current sensor **60**. The current sensor **60** is electrically coupled in series between a positive voltage terminal of the battery pack **30** and a first end of the contact **500**.

Referring to FIGS. **1**, **4-6**, and **13-16**, a flowchart of diagnostic method for the driver circuit **40** of the electric vehicle **10** when at least one of the main contactor coil **502**, the grounding contactor coil **512**, and the pre-charge contactor coil **522** are energized will now be explained. For purposes of simplicity, the following diagnostic method will be explained with reference to the main contactor coil **502** and the first and second voltage drivers **180**, **182** for controlling the main contactor coil **502**. However, it should be understood that the following diagnostic method can be utilized with grounding contactor coil **512** and/or the pre-charge contactor coil **522** and the associated voltage drivers therewith.

At step **1300**, the driver circuit **40** has the first voltage driver **180**, the second voltage driver **182** and the microprocessor **170**. The first voltage driver **180** has the input line **202**, the output line **204**, and the voltage sense line **206**. The input line **202** is coupled to both the first voltage driver **180** and the microprocessor **170**. The output line **204** is coupled to a first side of the contactor coil **502** of the contactor **50**. The voltage sense line **206** is coupled to both the output line **204** and to the microprocessor **170**. The second voltage driver **182** has the input line **262**, the output line **264**, and the voltage sense line **268**. The input line **262** is coupled to the microprocessor **170**. The output line **264** is coupled to a second side of the contactor coil **502**. The voltage sense line **268** is coupled to microprocessor **170**, and is electrically coupled to the output line **264** via the transistor **280**.

At step **1302**, the microprocessor **170** sets each of the first, second, third, fourth, fifth, and sixth diagnostic flags to an initial value. In one exemplary embodiment, the initial value is a Boolean logic value of "0." After step **1302**, the method advances to step **1304**.

At step **1304**, the microprocessor **170** generates a first pulse width modulated signal **603** on the input line **202** to induce the first voltage driver **180** to output a second pulse width modulated signal **653** on the output line **204** that is received by the first side of the contactor coil **502**. After step **1304**, the method advances to step **1306**.

At step **1306**, the microprocessor **170** generates a first signal **702** on the input line **262**, while generating the first pulse width modulated signal, to induce the second voltage driver **182** to receive an electrical current from the contactor coil **502** on the output line **264** which energizes the contactor coil **502**. After step **1306**, the method advances to step **1320**.

At step **1320**, the microprocessor **170** iteratively measures a voltage on the voltage sense line **206** over time to obtain a first plurality of voltage values when the microprocessor **170** is generating the first pulse width modulated signal **603**. After step **1320**, the method advances to step **1322**.

At step **1322**, the microprocessor **170** determines a first filtered voltage value based on the first plurality of voltage values utilizing a first filter equation. In one exemplary embodiment, the first filter equation is a first order lag filter equation. For example, in one exemplary embodiment, the first filter equation is as follows: first filtered voltage value=first filtered voltage value$_{Old}$+(voltage value of one of first plurality of voltage values−first filtered voltage value$_{Old}$) *Gain$_{Calibration}$. It is noted that the foregoing equation is iteratively calculated utilizing each of the voltage values of the first plurality of voltage values. After step **1322**, the method advances to step **1324**.

At step **1324**, the microprocessor **170** iteratively measures a voltage on the voltage sense line **268** over time to obtain a second plurality of voltage values when the microprocessor **170** is generating the first pulse width modulated signal **603**. The voltage on the voltage sense line **268** is indicative of a voltage on the output line **264** (e.g., voltage on output line **264**=voltage on voltage sense line **268**+voltage drop across the transistor **280**) when the transistor **280** is turned on. After step **1324**, the method advances to step **1326**.

At step **1326**, the microprocessor **170** determines a second filtered voltage value based on the second plurality of voltage values utilizing a second filter equation. In one exemplary embodiment, the second filter equation is a first order lag filter equation. For example, in one exemplary embodiment, the second filter equation is as follows: second filtered voltage value=second filtered voltage value$_{Old}$+(voltage value of one of second plurality of voltage values−second filtered voltage value$_{Old}$)*Gain$_{Calibration}$. It is noted that the foregoing equation is iteratively calculated utilizing each of the voltage values of the second plurality of voltage values. After step **1326**, the method advances to step **1328**.

At step **1328**, the microprocessor **170** makes a determination as to whether the first filtered voltage value is less than a first threshold value indicating that the first voltage driver **180** is undesirably shorted to a low voltage. If the value of step **1328** equals "yes", the method advances to step **1330**. Otherwise, the method advances to step **1340**.

At step **1330**, the microprocessor **170** sets a first diagnostic flag equal to a first value. In one exemplary embodiment, the first value is a Boolean logic value of "1." After step **1330**, the method advances to step **1332**.

At step **1332**, the microprocessor **170** makes a determination as to whether the second filtered voltage value is greater than a second threshold value indicating that the second voltage driver **182** is undesirably shorted to a high voltage. If the value of step **1322** equals "yes", the method advances to step **1334**. Otherwise, the method advances to step **1340**.

At step **1334**, the microprocessor **170** sets a second diagnostic flag equal to a second value. In one exemplary embodiment, the second value is a Boolean logic value of "1." After step **1334**, the method advances to step **1340**.

Referring again to step **1328**, if the value of step **1328** equals "no", the method advances to step **1340**. At step **1340**, the microprocessor **170** makes a determination as to whether the first diagnostic flag is set equal to the first value, and whether the second diagnostic flag is set equal to the second value, indicating that the contactor coil **502** is being energized by a reversed polarity voltage. If the value of step **1340** equals "yes", the method advances to step **1342**. Otherwise, the method advances to step **1344**.

At step **1342**, the microprocessor **170** stops generating the first pulse width modulated signal **603** and the first signal **702** to de-energize the contactor coil **502**. After step **1342**, the method is exited.

Referring again to step **1340**, if the value of step **1340** equals "no", the method advances to step **1344**. At step **1344**, the microprocessor **170** makes a determination as to whether the second filtered voltage value is greater than a third threshold value indicating that the second voltage driver **182** is undesirably shorted to a high voltage. If the value of step **1344** equals "yes', the method advances to step **1346**. Otherwise, the method advances to step **1352**.

At step **1346**, the microprocessor **170** sets a third diagnostic flag equal to a third value. In one exemplary embodiment, the third value is a Boolean logic value of "1." After step **1346**, the method advances to step **1348**.

At step **1348**, the microprocessor **170** makes a determination as to whether the first filtered voltage value is greater than a fourth threshold value indicating that the first voltage driver **180** is undesirably shorted to a high voltage. If the value of step **1348** equals "yes", the method advances to step **1350**. Otherwise, the method advances to step **1352**.

At step **1350**, the microprocessor **170** sets a fourth diagnostic flag equal to a fourth value. In one exemplary embodiment, the fourth value is a Boolean logic value of "1." After step **1350**, the method advances to step **1352**.

Referring again to step **1344**, if the value of step **1344** equals "no", the method advances to step **1352**. At step **1352**, the microprocessor **170** makes a determination as to whether the fourth diagnostic flag is set equal to the fourth value indicating that the first voltage driver **180** is undesirably shorted to a high voltage, and whether the third diagnostic flag is set equal to the third value indicating that the second voltage driver **182** is undesirably shorted to a high voltage. If the value of step **1352** equals "yes', the method advances to step **1370**. Otherwise, the method advances to step **1372**.

At step **1370**, the microprocessor **170** stops generating the first pulse width modulated signal **603** and the first signal **702** to de-energize the contactor coil **502**. After step **1370**, the method is exited.

Referring again to step **1352**, if the value of step **1352** equals "no", the method advances to step **1372**. At step **1372**, the microprocessor **170** makes a determination as to whether the first filtered voltage value is greater than a fifth threshold value indicating that the first voltage driver **180** is undesirably shorted to a high voltage. If the value of step **1372** equals "yes", the method advances to step **1374**. Otherwise, the method advances to step **1382**.

At step **1374**, the microprocessor **170** sets a fifth diagnostic flag equal to a fifth value. In one exemplary embodiment, the fifth value is a Boolean logic value of "1." After step **1374**, the method advances to step **1376**.

At step **1376**, the microprocessor **170** determines a first filtered current value based on the second plurality of voltage values. In one exemplary embodiment, the first filtered current equation is a first order lag filter equation. For example, in one exemplary embodiment, the first filtered current equation is as follows: first filtered current value=first filtered current value$_{Old}$+((voltage value of one of second plurality of voltage values/resistance of resistor **282**)−first filtered current value$_{Old}$))*Gain$_{Calibration}$. It is noted that the foregoing equation is iteratively calculated utilizing each of the voltage values of the second plurality of voltage values. The first filtered current value is indicative of an amount of electrical current flowing through the contactor coil **502**. After step **1376**, the method advances to step **1378**.

At step **1378**, the microprocessor **170** makes a determination as to whether the first filtered current value is less than a sixth threshold value. If the value of step **1378** equals "yes", the method advances to step **1380**. Otherwise, the method advances to step **1382**.

At step **1380**, the microprocessor **170** sets a sixth diagnostic flag equal to a sixth value. In one exemplary embodiment, the sixth value is a Boolean logic value of "1." After step **1380**, the method advances to step **1382**.

Referring again to step **1372**, if the value of step **1372** equals "no", the method advances to step **1382**. At step **1382**, the microprocessor makes a determination as to whether the fifth diagnostic flag is set equal to the fifth value, and whether the sixth diagnostic flag is set equal to the sixth value, indicating that the amount of electrical current flowing through the contactor coil **502** is less than a desired electrical current level that maintains a closed operational state of the contactor **50**. If the value of step **1382** equals “yes’, the method advances to step **1384**. Otherwise, the method is exited.

At step **1384**, the microprocessor **170** stops generating the first pulse width modulated signal **603** and the first signal **702** to de-energize the contactor coil **502**. After step **1384**, the method is exited.

The driver circuit **40** and the diagnostic method provide a substantial advantage over other circuits and methods. In particular, the driver circuit **40** and the diagnostic method provide a technical effect of determining when a first voltage driver is shorted to a low voltage and a second voltage driver is shorted to a high voltage.

The above-described diagnostic method can be at least partially embodied in the form of one or more computer readable media having computer-executable instructions for practicing the methods. The computer-readable media can comprise one or more of the following: hard drives, RAM memory, flash memory, and other computer-readable media known to those skilled in the art; wherein, when the computer-executable instructions are loaded into and executed by one or more computers or microprocessors, the one or more computers or microprocessors become an apparatus for practicing the methods.

While the claimed invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the claimed invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the claimed invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the claimed invention is not to be seen as limited by the foregoing description.

What is claimed is:

1. A driver circuit for an electric vehicle, comprising:

a first voltage driver having a first input line, a first output line, and a first voltage sense line; the first input line coupled to both the first voltage driver and a microprocessor, the first output line coupled to a first side of a contactor coil of a contactor, the first voltage sense line coupled to both the first output line and to the microprocessor;

a second voltage driver having a second input line, a second output line, and a second voltage sense line; the second input line coupled to the microprocessor, the second output line coupled to a second side of the contactor coil, the second voltage sense line coupled to the microprocessor;

the microprocessor configured to generate a first pulse width modulated signal on the first input line to induce the first voltage driver to output a second pulse width modulated signal on the first output line that is received by the first side of the contactor coil to energize the contactor coil;

the microprocessor further configured to iteratively measure a voltage on the first voltage sense line over time to obtain a first plurality of voltage values when the microprocessor is generating the first pulse width modulated signal;

the microprocessor further configured to determine a first filtered voltage value based on the first plurality of voltage values;

the microprocessor further configured to set a first diagnostic flag equal to a first value if the first filtered voltage value is less than a first threshold value;

the microprocessor further configured to iteratively measure a voltage on the second voltage sense line over time that is indicative of a voltage on the second output line to obtain a second plurality of voltage values when the microprocessor is generating the first pulse width modulated signal;

the microprocessor further configured to determine a second filtered voltage value based on the second plurality of voltage values;

the microprocessor further configured to set a second diagnostic flag equal to a second value if the second filtered voltage value is greater than a second threshold value; and

the microprocessor further configured to stop generating the first pulse width modulated signal to de-energize the contactor coil if the first diagnostic flag is set equal to the first value, and the second diagnostic flag is set equal to the second value.

2. The driver circuit of claim **1**, wherein the microprocessor is further configured to generate a first signal on the second input line to induce the second voltage driver to receive an electrical current from the contactor coil on the second output line to energize the contactor coil.

3. The driver circuit of claim **2**, wherein the microprocessor is further configured to stop generating the first signal to de-energize the contactor coil if the first diagnostic flag is set equal to the first value, and the second diagnostic flag is set equal to the second value.

4. The driver circuit of claim **2**, wherein the first signal has a high logic voltage while the first pulse width modulated signal is being generated.

5. The driver circuit of claim **1**, wherein when the first diagnostic flag is set equal to the first value and the second diagnostic flag is set equal to the first value, the first diagnostic flag indicates that the first voltage driver is shorted to a low voltage, and the second diagnostic flag indicates that the second voltage driver is shorted to a high voltage, such that the contactor coil is being energized by a reversed polarity voltage.

6. The driver circuit of claim **1**, wherein the second threshold value is greater than the first threshold value.

7. The driver circuit of claim **1**, wherein the second voltage sense line is electrically coupled to the second output line utilizing a transistor.

8. A diagnostic method for a driver circuit for an electric vehicle, the driver circuit having a first voltage driver, a second voltage driver, and a microprocessor; The first voltage driver having a first input line, a first output line, and a first voltage sense line; the first input line coupled to both the first voltage driver and the microprocessor, the first output line coupled to a first side of a contactor coil of a contactor, the first voltage sense line coupled to both the first output line and to the microprocessor; the second voltage driver having a second input line, a second output line, and a second voltage sense line; the second input line coupled to the microprocessor, the second output line coupled to a second side of the contactor coil, the second voltage sense line coupled to the microprocessor; the method comprising:

generating a first pulse width modulated signal on the first input line utilizing the microprocessor to induce the first voltage driver to output a second pulse width modulated signal on the first output line that is received by the first side of the contactor coil to energize the contactor coil;

iteratively measuring a voltage on the first voltage sense line over time utilizing the microprocessor to obtain a first plurality of voltage values when the microprocessor is generating the first pulse width modulated signal;

determining a first filtered voltage value based on the first plurality of voltage values utilizing the microprocessor;

setting a first diagnostic flag equal to a first value if the first filtered voltage value is less than a first threshold value utilizing the microprocessor;

iteratively measuring a voltage on the second voltage sense line over time that is indicative of a voltage on the second output line utilizing the microprocessor to obtain a second plurality of voltage values when the microprocessor is generating the first pulse width modulated signal;

determining a second filtered voltage value based on the second plurality of voltage values utilizing the microprocessor;

setting a second diagnostic flag equal to a second value if the second filtered voltage value is greater than a second threshold value utilizing the microprocessor; and

stopping the generating of the first pulse width modulated signal to de-energize the contactor coil if the first diagnostic flag is set equal to the first value and the second diagnostic flag is set equal to the second value, utilizing the microprocessor.

9. The diagnostic method of claim **8**, further comprising generating a first signal on the second input line utilizing the microprocessor to induce the second voltage driver to receive an electrical current from the contactor coil on the second output line to energize the contactor coil.

10. The diagnostic method of claim **9**, further comprising stopping the generating of the first signal utilizing the microprocessor to de-energize the contactor coil if the first diagnostic flag is set equal to the first value, and the second diagnostic flag is set equal to the second value.

11. The diagnostic method of claim **9**, wherein the first signal has a high logic voltage while the first pulse width modulated signal is being generated.

12. The diagnostic method of claim **9**, wherein when the first diagnostic flag is set equal to the first value and the second diagnostic flag is set equal to the first value, the first diagnostic flag indicates that the first voltage driver is shorted to a low voltage, and the second diagnostic flag indicates that the second voltage driver is shorted to a high voltage, such that the contactor coil is being energized by a reversed polarity voltage.

13. The diagnostic method of claim **8**, wherein the second threshold value is greater than the first threshold value.

14. The diagnostic method of claim **8**, further comprising turning on a transistor to electrically couple the second voltage sense line to the second output line.

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